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The Autonomous Sciencecraft Experiment: Monitoring of Geological and Environmental Hazards With An Autonomous, Intelligent Spacecraft.

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http://ASE.jpl.nasa.gov

1. What is ASE?

The Autonomous Sciencecraft Experiment (ASE) [1-3] is being flown on the New Millennium Program Earth Observing 1 (EO-1) spacecraft, currently in Earth orbit. ASE is a NASA New Millennium Program experiment, part of the Space Technology-6 Project. ASE addresses problems of increasing volumes of data overwhelming Deep Space Network resources, and inability of spacecraft to react quickly to data of high scientific interest. ASE demonstrates and tests the following capabilities:

1. Autonomous on-board data processing
   - Change Detection
   - Re-Targeting
   - Selective data return
2. Autonomous spacecraft command and control, and fault recovery
3. Autonomous science-driven operations and resource management

2. ASE Components

ASE is comprised of three parts:

1. An onboard planner that handles requests and resources.
2. Spacecraft Command Language to operate the spacecraft.
3. Science Classifiers to process the data and detect high-value targets.

Primary target processes are selected which have extraterrestrial analogs (ice formation, clouds, volcanism, floods).

3. ASE on EO-1 in Earth-Orbit

ASE is flying on the NASA NMP Earth Observing 1 (EO-1) spacecraft and processes data from the Hyperion hyperspectral imager

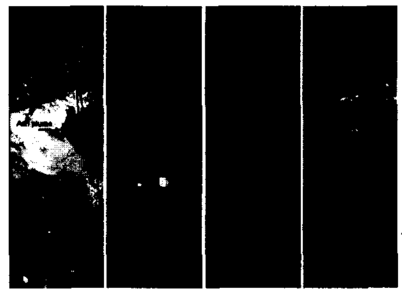
EO-1
Launched in 1999 into the same high-inclination orbit as Landsat-7 (1 min behind). Exact repeat track = 16 days. Can obtain data 1 and 2 paths off-track.

Hyperion hyperspectral imager
7.7km x 30 km swath at 30 m spatial and 10 nm spectral resolutions over 400-2500 nm spectral range

4. Science Data Classifiers

The ASE Science Classifiers utilise up to 12 bands of Hyperion data (226 bands covering 0.4 to 2.5 microns) to classify scenes onboard EO-1 on the basis of spectral signature. If the number of process pixels exceeds a set threshold, then a request is generated for more data and prioritized data return.

5. Volcanic Thermal Emission Detection

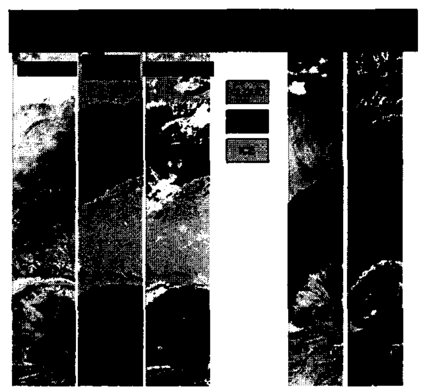


Belinda, Montagu Island, South Sandwich Islands: 7 Dec 2003

Hyperion is especially sensitive to thermal emission from effusive volcanism. ASE thermal classifiers are used to detect and monitor volcanic activity. The number of hot pixels and the intensity of activity are ASE classifier outputs.

This observation is one of a sequence showing an eruption in progress. Extraterrestrial analogues are found on the jovian moon Io.

6. Snow-Water-Ice-Land (SWIL)

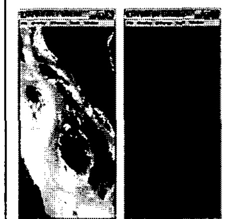


Frozen lake classified as ice (right image)

Thawed lake classified as water (right image)

The SWIL classifier uses 5 to 7 bands to accurately differentiate between clouds, snow, water, ice and land. Formation of lake and sea ice, and amount of snow cover, are monitored using this classifier. Extraterrestrial analogues are found on Mars, Europa, and possibly other icy satellites.

7. Flood Detection

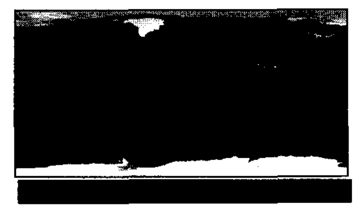


The Flood Classifiers are described in detail by Ip *et al.* (2004) [5]. The images to the left show the Brahmaputra river, India, and the output from the water classifier. This is used to detect flood events at a number of river systems around the world, as well as controlled flooding events in the United States.

8. Vegetation Cover

The vegetation classifier is described in Lee *et al.* 2004 [6]. This classifier does not have an extraterrestrial analog, but can be used for terrestrial hazard damage assessment, and for returning vegetation after catastrophic volcanic, fire or flood events.

9. Targets and EO-1 operations in 2004



1. During 2004 EO-1 will obtain over 300 observations of targets for ASE, with this allocation divided between processes managed by JPL, ASU and U. Arizona. Data and classifier output will be validated on the ground by the ASE Science Team.
2. Initial observation-trigger-response sequences are being used for software testing and technology validation.
3. Later sequences will involve more sophisticated responses, including:
   a. nighttime volcano observations
   b. Observation of upstream and downstream sites from flooded areas to determine extent and impact of event
   c. Observations of lower-elevation areas or lower latitude areas from an ice-thaw (or freeze) trigger
   d. sequences designed to maximise temporal coverage of dynamic processes

10. References

[1] Chien, S. *et al.* (2003) "Autonomous Science on the EO-1 Mission", Proceedings of I-SAIRAS 2003, 7th International Symposium on Artificial Intelligence, Robotics and Automation in Space, Nara, Japan.
[2] Davies, A. G. *et al.* (2001) ASC Science Study Report, available from http://ASE.jpl.nasa.gov
[3] Davies, A. G. *et al.* (2002) *LPSC-33* abstract 1130, on CD-ROM.
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[6] Lee, R. J. *et al.*, (2004) *LPSC-35* abstract 1615, on CD-ROM.

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